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EET 218 ENGINEER IN SOCIETY LECTURE

1.0 INTRODUCTION TO SCIENCE, TECHNOLOGY AND ENGINEERING

The three words – Science, Technology and Engineering are so related that most times they are used interchangeably, making it almost impossible for people to know their actual meanings.

1.1 **PHILOSOPHY:** According to MS Dict Viewer Dictionary, Philosophy is defined as:

(1) The study of the fundamental nature of knowledge, reality, and existence.

(2) An attitude that guides one's behaviour.

Philosophy originated from the Greek word, "Philosophia" meaning, "love of wisdom."

Philosophy of Science is the study of the meaning of Science.

1.2 THE MEANING OF SCIENCE

The tendency of human beings and in fact other lower animals to probe and understand their environment is as old as creation or evolution. The life of a new born baby revolves around exploring his environment and this is why most babies are fascinated by sharp colours, bright light, moving objects and songs.

Sometimes, the search for knowledge produces only facts on how and not necessarily on why things happen. In general, things that cannot be explained are accepted as facts. For example, it is a fact that night and day alternate within every twenty-four hours, rain falls during a certain period of the year, objects fall to the ground each time they are thrown up, the solar system maintains a certain order, the human organs function in a certain manner, etc.

Scientific principles and laws are used to explain all aspects of human existence and the universe. This has led to the division of science into:

* **Physical Science** – this deals with the relationship between bodies and objects that are not living such as the principles guiding the behaviour of metals, chemicals, sand, water, air and other physical phenomena.
* **Biological Science** – this deals with understanding how and why living things function the way they do, e.g. the functioning of the human body, other animals, plants and related things.
* **Social Science** – this deals with the laws of human behaviour which cannot be qualified physically.
* **Management Science** – this deals with the knowledge that covers procedures for modern day management of human and material resources.

Scientific ideas and laws are varied. Ideas that may not have any practical application are referred to as "**Pure Science**," while those that have practical application are referred to as "**Applied Science**." It is the application of science that gives physical meaning to knowledge resulting in a technological and engineering application, e.g. the law of conservation of energy (energy can neither be created nor destroyed but can be converted to other forms of energy) became useful when the knowledge was applied in converting heat energy to kinetic energy resulting in the development of the technology of engines.

1.3 THE MEANING OF TECHNOLOGY

The word "Technology" has been used to mean different things to different people and circumstances. Thus different authors have seen technology from different view points as shown below:

- Spier (1968) – stated that "... technology embraces the means by which man controls or modifies his natural environment."
- Toffler (1970) – sees technology as, "that great growling engine of change."
- Avensberg and Niehoff (1971) agrees that "the technology of people is their major means of adjusting to the environment."
- Popenoe (1971) – thinks that technology is " a special kind of knowledge which is directed towards practical applications in the physical and social world."
- Lenski and Lenski (1979) – defines technology as the information, techniques and tools with which people utilize the material resources of their environment to satisfy their various needs and desires."
- Hanks (1979) – it is the application of practical or mechanical sciences to industry or commerce.
- Pytlik (1985) – defines technology as "a study of the technical means undertaken in all cultures which involves the systematic application of organized knowledge and tangibles (tools and materials) for the extension of human faculties that are restricted as a result of the evolutionary process."
- Unknown Author – defines technology as "the technical know-how, scientific ideas, information, knowledge, materials or goods and services capable of being systematic and sequential in its

generation; communicable and adaptable to application in a given economic, political, social and cultural milieu."

From the above definitions, we can conclude that technology refers to the body of organized knowledge, tools and machines used by man to manipulate his environment to satisfy his basic needs.

Many writers erroneously identify technology with only the hardware (machines and technical devices) of production and services. This has led to the misconception that Faculties or Universities of Technology have no business offering courses like management and law. This view is wrong as technology is much more than the hardware component – it also has the "software" components for production and services, that is, the management practices which are needed to achieve efficient production rate that helps realise production targets whether goods or services. In a soap manufacturing company, for an instance, the technology used by the firm include the machines/facilities and processes used for production as well as the management techniques used for production, storage, marketing and distribution of the products. Technology, therefore, extends to law, administration, banking, education, etc.

Technology is one of the major inputs which facilitates the increase in the production of goods and services. Its absence at an intermediate or advanced level has been known as a major constraint to many facets of development. Nigerian economy is in trouble today because technology in Nigeria is still at its infancy (lower level) and nothing to write home about. We have basically all the needed raw materials to produce all forms of goods and services but we lack the technological hardwares

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and to some extent soft wares to transform these nature given materials to meet our basic needs and desires.

It's worthy to note that no matter the primitivity of a people and their culture, there exists some level of technology which is dynamic from one generation to another.

Science and Technology by themselves cannot achieve practical goals. It is only when they are matched by an appropriate engineering background that useful practical goals and services are produced.

1.4 THE MEANING OF ENGINEERING

The engineering profession is one of the oldest professions in the world. Its major objective is to utilize the available resources of nature to restore the dignity of man by improving the comfort, timelessness of operations and removing the drudgery usually associated with the performance of labour intensive, time-consuming activities of mankind.

According to MS Dict Viewer dictionary, engineering is defined as "the branch of science and technology concerned with the design, building, and use of engines, machines and structures." It has also been referred to as the application of science, technology, art and economics to the definition and solution of real social-economical and ecological problems. Because of the nature of human problem, the application of the knowledge is in the areas of conception, design development, manufacture, selection, testing, adoption, operation, maintenance of machine, implements, equipment, tools, structures and systems aimed at improving the infrastructural, technological, economic and complete mechanization of the activities of humanity.

The activities of the engineer are multifarious and as broad as one can imagine. The engineering profession is perhaps the most important profession, as the achievements and products of engineering can be easily witnessed in all facets of human activities-just name it!

The level of engineering practice in a nation is the major index of that nation's level of development. Engineering advancement also advances technological, military, economic and infrastructural developments of a nation. The nations of the world are grouped as developed and developing or as first, second and third world countries.

These classifications are based on the level of engineering sophistication and technological development. The most advanced countries in engineering and technology became the first world or the developed nations while those countries with least engineering and technological development like Nigeria, earn the title of the "third world" or developing nations.

There is enough indication in the world today, that any nation which neglects the development of her engineering facilities and personnel is relegating her citizen and future, technologically, economically and infrastructurally.

1.5 THE RELATIONSHIP BETWEEN SCIENCE, TECHNOLOGY AND ENGINEERING

From the above discussion, it is seen that while science seeks to know and understand why things happen, technology tells us how they happen while engineering actually makes them happen. The link between the three is so strong and close that sometimes they are used interchangeably. This link has to be recognized and nurtured for any

nation to move towards the path of sustainable development. If any of the tripartite links is missing, development will be stalled.

In Nigeria today, there are many examples of this missing link. There are many processes for which we have the scientific knowledge, the technology is also available (to some degree) but because we lack the engineering capability, the project gets into trouble as soon as the technical partners withdraw and we are forced to go back, setting up a cycle of technology dependence. The power sector in Nigeria is a typical example. The science of power generation, transmission and distribution is very much understood by many electrical and mechanical engineers trained in these areas. The hardware and software of electricity generation technology have been imported, installed and operated by our engineers and technologists. However, the engineering capability is very much lacking. Thus whenever any of the sensitive machines breakdown, the machines are grounded until spare parts are ordered and flown in from abroad and at times technical personnel are also invited from the technical partners.

Because of this relationship between science, technology and engineering, each one is used to develop the other and vice versa. In some situations, science led to the advancement of technology and subsequently engineering practice while in others, the process is reversed, that is, by studying processes and machines, new areas of science have been developed. The biggest problem facing technological development in Nigeria today is how to make this link between science, technology and engineering to be strong and effective. Science by itself is useless unless it can be translated through technology and engineering to useful production and services.

1.6 HISTORICAL DEVELOPMENT OF TECHNOLOGY AND ENGINEERING

The historical development of technology and engineering by man has been more of a gradual process from primitive technology at stones and sticks to the present day high technology of computers and space travel.

The stages in the development of world technology can be identified to include the Stone age, Bronze age, Iron age, Middle / Dark age, Industrial Revolution, Adamic age, Space age and Computer age. Primitive technology was developed during the stone age which spanned through the Paleothic and Mesolithic periods in history. Tools developed within this period were made of stones, wood and bones. These tools were limited in operation. As the need for better provision of the three basic necessities of life (food, shelter, and clothing) increased, the need for better tools also increased.

During the Neolithic period of civilization (3500 – 1000 BC), the following metals were discovered-copper, bronze, iron. The use of metals was a great improvement over the use of stones because they could be shaped into any form and could absorb larger forces. This led to the discovery of the six basic machines on which modern technology is based namely lever, wedge, inclined plane, pulley, wheel, axle and screw. The Middle/Dark Ages followed the metal ages with the collapse of the Roman Empire. Communities were more or less self reliant within this period. Fairs were introduced in Europe at this time. This brought technologies developed elsewhere like China into Europe. Technologies introduced within this period include water wheels, wind mills, ships, ploughs, printing technology, etc.

In the 19th Century, the industrial revolution occurred in Europe and North America as a result of the discovery of steam engine in England by the middle of the 18th Century. This led to the development of different technologies such as mining, shipping, advanced forms of transportation. The invention of the electric motor in 1821 by Michael Faraday replaced the steam engine as the major prime mover for many factory steam turbine while the invention of the internal combustion engine by Rudolph Diesel in 1893 replaced the steam engines as major power source for transportation. With these machines running the heavy industries, many products were developed, better processes were developed and the human mind was able to think about other things. Many advanced technologies such as power generation from nuclear energy were developed during this era. With this high technology revolution came the need for precise controls and monitoring of the new complicated machines.

Many electronic devices were next developed in the mid – 20th century thus paving way to the development of the ENIAC (Electronic Numerical Integrator and Computer) by Presper Eckert JR and John Manchly. Since the introduction of the computer and other electronics, many technological products and services have been introduced which have affected the society in many ways as machines aid every aspect of human existence today.

In Nigeria, the development of technology and engineering practice dates back pre-history times and subsequently followed the development of empires and kingdoms in pre-colonial time. Modern technology and engineering came with colonization and gradually replaced what was existing. In order to exploit the resources of the

hinterland, the colonialist, who came through the coast, built roads, water ways, bridges and railways all over the country. In addition, public utilities were established including electricity, water, schools, and transportation system. In order to maintain these infrastructure, the then public works Department (PWD) was created. Today, there are federal ministries of works and housing, Industries, Science and Technology, agriculture, water resources, Aviation, Commercial, etc. all involved in the development and management of technologies and engineering related activities. Engineering and Technology have also grown considerably in the private sector of the Nigerian economy over the years in the areas of:

* Petroleum sector:- NNPC, Shell, Mobil, Total, Chevron, etc.
* Road construction:- Julius Berger and Belfinger, Feugerolle Feugerolle, RCC, MCC, etc.
* Automobile:- Peugeot Automobile Nigeria (PAN), ANAMCO, Sterr, Michelin, Dunlop, etc.

In addition to the above, there are many Schools, Polytechnics, Colleges and Universities all over the country who are teaching the principles involved in engineering and technology practice.

2.0 THE ENGINEER AS AN ARTIST

The pioneers of the engineering profession were more of artists than science based engineers. This was probably why the British Institution of Civil Engineers in 1824, defined Civil Engineering as, " ... the art of directing, the great sources of power in nature for the use and convenience of man". In the beginning, engineering was practiced as an art based on talent, skill and experience. Many of the professionals at that time were carpenters, masons, instrument makers, irrigation operators, technicians, blacksmiths, etc.

Even in modern day practice of engineering, we note that although the science – based engineer may have a good number of scientific formulae, principles and procedures, the end product of any engineering work is more of an art, inventiveness and creativity than science. The actual design involves the personal touch of the designer, although he/she is guided by established scientific laws and principles. Examples of the role of the engineer as an artist can be seen by observing some unique buildings in Nigeria such as:

- National Theater, Lagos
- Central Mosque, Minna
- Headquarters of the multinationals in Lagos and Abuja.
- National Christian Centre Abuja/National Mosque Abuja.

2.1 THE ENGINEERING FAMILY

In every human setting where a group of people come to work together to achieve a common goal, there is always some kind of division of labour and hierarchy. The biological family of which every body belongs is a typical example. There is a father, mother, children, house-help, relation, etc. Each

member of the family is distinct and has a specific indispensable role to play. Where any member is absent or is not performing his or her duties well, the overall output of the family suffers.

The group of people who carry out engineering activity in Nigeria can be classified into what Faluyi (1993) called the "Engineering Family." Just like in family, the engineering family can only succeed if each member of the family understands and plays his role effectively. In most cases the roles are clear but sometimes they overlap.

The Council for the Regulation of Engineering in Nigeria (COREN) recognizes four cadres in engineering professional practice in the country. These four cadres that make up the engineering family are:

- Craftsman / Artisan
- Technician
- Technologist
- Engineer.

2.2.1 CRAFTSMAN / ARTISAN

Though the craftsman is at the bottom of Engineering family hierarchy, he/she is the most important member of the family. He makes use of his hands and he/she is highly skilled in one or more aspects of engineering practice to an extent that he can recognize and use engineering tools and materials for production and services in a plant or engineering work. The craftsman cadre includes masons, carpenters, mechanics, electricians, fitters, plumbers, machine operators, etc. These are the people that actually do the final phase of any engineering work.

Although a craftsman is expected to undergo a certificate vocational training in his chosen area after primary school and junior secondary school, he is mostly trained on the Job in Nigeria.

2.2.2 TECHNICIAN

A technician is formally trained in a technical college level in more than one specific art or engineering practice. He is usually the direct supervisor of the craftsman. He is expected to hold an Ordinary National Diploma (OND), National Diploma (ND) or a Final City and Guilds Certificate (London) earned from a College of Technology or Polytechnic. He is either a foreman in a construction site, a supervisor in a factory, a head of a maintenance team, head of quality control, or what have you. Whereas a craftsman specializes in a specific trade, the technician is more versatile and is expected to supervise the works of many different craftsmen under him.

2.2.3 TECHNOLOGIST

The technologist has a higher training than the technician, usually up to Higher National Diploma (HND) in a Polytechnic or College of Technology, or other relevant institutions. In industry, they function partly as operatives and partly as managers. Usually, they possess most of the skills of artisans plus some level of analytical skills of the engineers.

2.2.4 ENGINEER

The engineer is the head of the engineering family and he is usually a holder of a Bachelor's degree in engineering and sometimes higher degree (Masters or Ph.D.). By training, he possesses mostly analytical and managerial skills to design, analyse and manage engineering systems including men and materials. He may not necessarily be detailed or knowledgeable in the skills of

the artisan but should be able to provide leadership, guidance and supervision. This is why in most establishments; engineers end up as managers, overseeing what is going on in different sections.

2.2.5 THE ENGINEERING FAMILY IN A TYPICAL INDUSTRY

For effective co-ordination of engineering activities in a typical industry, there exists a formal chain of command between the different members of the engineering family as shown below in fig. 1.

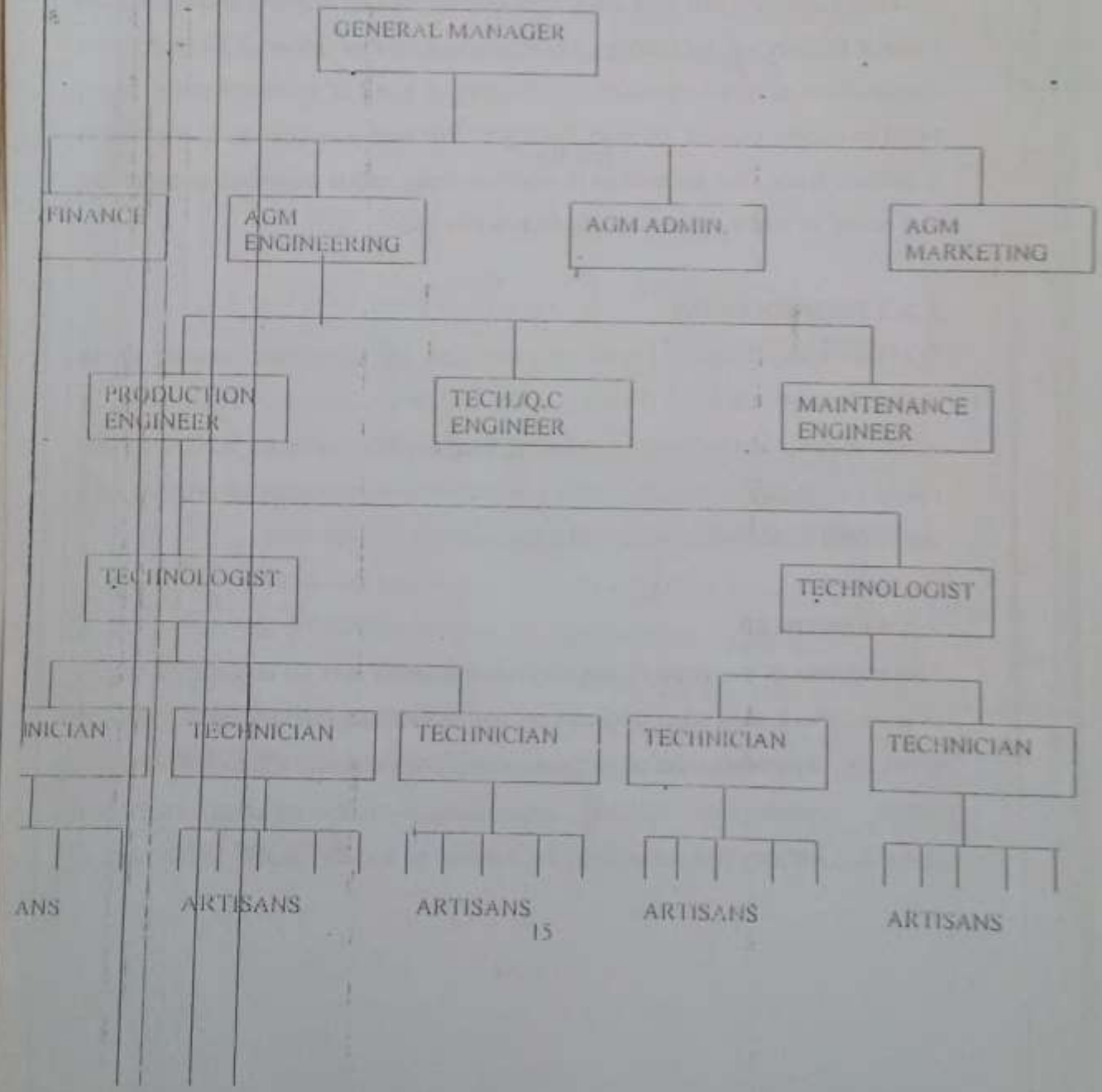

Fig. 1: The Engineering Family at Work in a Typical Industry.

The above figure shows that in practice there are more technologists than engineers; more technicians than technologists and more artisans than technicians.

A kind of pyramidal technological structure such as shown in figure 2 below is maintained giving the ratio of Engineers : Technologists : Technicians : Artisans / Craftsmen as 1 : 2 : 4 : 8 (minimum ratio).

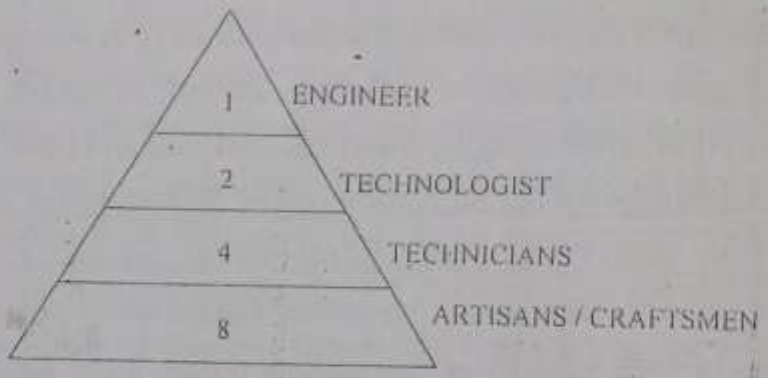

Fig.2: Ratio of Different Cadres of Engineering Profession

3.0 ENGINEER – IN – SOCIETY

The engineering profession is widely regarded as the most extensive and intensive profession covering almost all facets of human endeavour. The role of the engineers in society spans across politics, religion, technology, law, medicine; manufacturing, teaching, management, administration, defence, food production, and provision of utilities.

3.1 POLITICS

Earlier engineers abhorred politics believing that they were too busy with their tools to turn onto the rhetorics and troubles of politics and governance of man. He is much occupied with the whys and hows of the numerous problems hindering the development of man and his environment that he alienated himself from the idea of governance and the organization of man and materials believing that politics was best suited for those who had little to show from their strength, creativity, technical competence and practical ingenuity.

They forgot that politics and the associated powers of government are the pivot upon which their technical prowess and ingenuity lies. Politics is a serious game which only very serious-minded persons such as engineers must play for the greater advantage of the people. Politics, as we are aware, is a process and art of power struggle, power consolidation and power utilization. If one has technology but has no political power, his technology will be taken away from him through the might and policies of government. If one has money and has no political power, his money can be taken away. The same thing applies to one's freedom without political power, it can be violated and exchanged for imprisonment, restriction, etc.

The above suggest that political power is very important to the engineer to enable him gain the right environment to practice. It will enable the engineer to participate in policy formulation necessary for the advancement of the engineering profession.

3.2 AS A MEMBER OF THE SOCIETY

The engineer is first and foremost a member of his village, town, local government area, state, country, etc. He is, therefore, expected to do his duties as a member of his community. He is equally expected to make

meaningful contributions that advances ideas, knowledge and promote cordial existence between the different arms of the community.

The engineer must be seen to be honest in whatever he says and does with the members of the society. When called upon to head committees on engineering projects, he should participate diligently and exhibit good leadership. He should not compromise quality or connive with the contractor(s) to defraud the community.

3.3 RELIGION

The engineer – in – society needs to understand the religious beliefs of his environment and play an active part in its enhancement. He has to be spiritually religious in his behaviours and actions. Religious discipline is important in the daily co-existence of man and his neighbours as it promotes peace and tolerance. It is believed that when God stopped creation, he handed over His tools of creation to the engineer with the instruction to continue from where he stopped. That is why the engineer has created and can create virtually anything on earth today.

3.4 NEW TECHNOLOGY

Engineers are trained to solve the technological problems of man. Wherever he may be, the engineer is widely expected to proffer solutions to most technical problems of humanity: environmental problem; transportation problems (air, land and sea); automobile, telecommunication, electricity, roads, buildings, industrial constructions and maintenance.

In each of these areas, the engineer creates new technologies, both simple and complex, necessary to solve the challenging problems of the time.

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3.5 LAW

When laws are properly enforced, they promote peace and orderliness of human activities. A lawless society is often characterized by disorder, anarchy and confusion. The engineering profession hardly grows in state of lawlessness. In other words, the engineer requires a well established non-oppressive law to operate.

The engineer, however, needs to understand such laws as the contract laws, factory laws etc and the general laws of his country and is duty – bound to understand and obey them with strictest discipline if he must effectively practice his profession. It is as a result of this that a course on law of practice (MEE 515) must be taken by every engineering student in FUT Minna.

3.6 MEDICINE

The roles of the engineer in the development and sustenance of modern medicine is principally based on the design and manufacture of medical tools, equipment and machines. These range from the simplest tools such as syringes, needles, etc. to the complex radiological laboratory and pharmaceutical machines.

Because of these machines and equipment, it is widely believed that modern medicine heavily depends on the advancement of the engineering profession in order to carry out the diagnosis of health and medical problems of mankind most efficiently.

3.7 MILITARY FUNCTION

The military powers of a Nation are dependent on the level advancement of engineering and technology. The engineer designs produces the ammunition and many military machines necessary execute wars and maintain peace.

The engineer is also required to construct military structures such as trenches, roads, bridges, and build cars, trucks, etc. to move men and materials from one location to another.

3.8 ADMINISTRATION AND MANAGEMENT

The engineer should be fully involved in the administration and management of human and material resources in workshops and manufacturing industries. The recruitment of technical personnel, selection of production materials, machinery and equipment; performance testing of new machines / equipment; maintenance and repairs of machines and equipment; costs and engineering analysis of machines, equipment, processes, controls and techniques of production etc. are all the management and administration responsibilities of the engineer.

3.9 FOOD PRODUCTION

Perhaps the most important role of the engineer in the society is the production, processing and distribution of food. Engineers develop machines and systems that are used to produce crops and animals for food and fibre. When these are harvested, machines and structures developed by engineers are used to process and store the products, in factories, storage depots, etc.

3.10 UTILITIES

Most developed societies live in cities which require utilities such as roads, water, school, electricity, markets, drainage system, etc. These utilities are provided and maintained by engineers. The code of practice for engineers demands that professionals entrusted with these services should ensure that the interest of the society is placed above other interests.

4.0 SAFETY IN ENGINEERING PRACTICE

4.1 INTRODUCTION

Safety in engineering practice is very important so as to avoid the occurrence of accidents.

Definition of Accident: It is an unpleasant incident that happens unexpectedly. OR It is an incident that happens by chance.

Any event or incident that will lead to human death should be avoided at all cost. Accidents have been found to be the fourth leading cause of death in USA besides heart disease, cancer and strokes. However, in Nigeria it is safe to say that accident is number "one" cause of death. We should not only be conscious of it, we should all be seen to be doing everything to minimize it if we cannot completely eliminate it.

4.2 Types of accidents are:

(i) Motor vehicle accidents
(ii) Drowning
(iii) Fire
(iv) Falls
(v) Natural disasters
(vi) Work – related accidents
(vii) Poison (solid / liquid)

Workplace accidents (which is of interest to us), ranks second of all the above accidents as shown below:

1st	Motor vehicle
2nd	Workplace

3rd	Home
4th	Public

s rather unfortunate that globally, natural disasters which results in fewer aths/year will make better news headlines than the workplace accidents ch claims more than 10,000 deaths/year. It is said that, "while you make a minutes speech, 2 persons will be killed and 170 will suffer a disabling ry. On the average, there are 11 accidental death and about 1,030 bling injuries every hour during the year."

CAUSES OF ACCIDENTS IN ENGINEERING PRACTICE

ording to a survey carried out by H. W. Heinrich, on accident and their ses, the analysis show that:

88% accidents occur due to human causes such as unsafe practices, lack of foresight, wrong attitude, and to an average Nigerian, lack of patience, etc.

10% accidents occur due to mechanical failures such as poor condition of tools or equipment failure, etc.

2% accidents occur due to natural causes such as weather, flood, cyclones, hurricane, storm (in case of Nigeria) etc.

jeneral, the major causes of accidents in engineering practice can be iped into two, namely: unsafe acts and unsafe conditions.

unsafe acts are those actions of a person or persons in a workshop or ory that may result to an accident. Such acts may be unintentional or in e cases intentional. An example of unsafe acts is smoking in a room re petrol or inflammable substances are stored. It is an unsafe act for a ent to put sharp tools or instruments inside his or her pocket.

safe conditions in the workshop /factories are very dangerous. An unsafe ıdition is such a condition which may cause accident. The unsafe conditions ge from the physical conditions of the factory to the orderliness of the 'king equipment. Working with faculty equipment is a great risk. It is quite afe, for instance, to work with a grinding machine without the usual tective guard as some of the particles (either from the metal being ground he grinding stone material) lodging into the user's eyes.

ther example of an unsafe condition is the accidental flow or discharge of ıstrial oil or water on the floor of the factory. This could cause slippery litions which can cause one to a terrible fall that may result in broken es or serious injuries.

very engineering practice, materials, machines and man (human beings) act to produce goods and services. In order to reduce costs and optimize uction, serious attention must be paid to safety of materials, machines workers. Safety engineering is the reduction, control or elimination of all rdous conditions which pose a threat to life and property. There are al sources of hazardous conditions in an engineering establishment such factory, construction site, dam, etc. These include fire, machines, human vior, electricity, floor conditions /plant layout, environmental conditions ıse of chemicals.

. FIRE

s the most dangerous source of hazard in an industrial set-up. The es of fire can be from any section of the factory. In some engineering ces or applications, inflammable items are used in the process of facturing. These items can easily catch fire with little carelessness. g of metals using oxy-acetylene gas welding set or a grinding disc can fire. Arc welding is another source of fire in the factory. Electric spark is

common source of fire outbreak. Fire can also start from natural nenomenon such as earth quakes, lightening, rain or storm.

Safety engineering seeks ways of minimizing the possibility of these risks converting to actual fires and how to combat the fire if it eventually starts. This is necessary because in many cases, the effect of a fire is the permanent closing of a marginally operating business which is the primary life blood of the community. It has been estimated by insurance authorities, that over 40% of businesses experiencing a fire do not resume and 60% of those which reopen will shut down permanently after 1 year of operation. Further direct osses which may be experienced after a fire includes. .

- Curtailed sales due to lost production capability.
- Loss of key employees to competitors.
- Excessive replacement costs due to overtime and inability to buy at the most opportune moment.
- Loss of capital return in investments
- Continuance of fixed charges during shutdown.
- Cost of replacing depreciated buildings and equipment with new facilities.
- Loss of credit.

irst – aid Fire fighting equipment include portable fire extinguishers, andpipe and hose and specialized motorized fire equipment. The main factor) be considered in employee indoctrination is that the portable fire xtinguisher, or other equipment, must be considered only as a temporary easure for use between the fire discovery and the arrival of professional fire fighting personnel.

e extinguishers are of four classes, namely:

(i) CLASS "A": for fighting fires in ordinary combustibles such as wood, cloth, papers and many plastics. Extinguishers in this class include water pressure, water pump can, soda – acid and all purpose dry-chemical units.

(ii) Class "B": For fires in flammable or combustible liquids, gases, and similar materials. Extinguishers in this class include carbon dioxide, dry chemical, and vapourizing agents.

(iii) Class "C": For fires involving electrical equipment in the energized state of operation. Extinguisher in this class include carbon dioxide and dry chemical (agents used are non conducting to avoid electric shock).

iv) Class "D": For fires involving combustible metals such as magnesium, zirconium, sodium and potassium. The extinguishing agent provides a heat – absorbing medium which is not reactive with the metals.

.3.2 MACHINES

Machines are not human beings who are capable of thinking and taking intelligent decisions. They are designed to perform specific function which they religiously perform baring any malfunctioning of the components. It therefore, means that if any material that is not meant to enter the machine does so, that material can result to unsafe conditions. Machines are made of moving parts and these should be covered to avoid contacts with human beings. However, in some factories or workshop, it is not unusual to see belts, chains, gears and moving linkages left exposed without protection, such exposures can create unsafe environments for both workers, materials and the production machines themselves. It is worth to mention that modern machines are designed such that the safety guards or protectors are

interlocked with the machine operating system thus making it impossible to start the machine without the guards in position.

4.3.3 POWER SOURCES

Most industrial machines are powered by electric or hydraulic motors. The power supply is usually from the national grid of PHCN or from stand-by generators installed in the factory premises. Unsafe conditions can be created by intermittent power supply which sometimes is erratic with a voltage as high as 300V instead of 220V – 240V for domestic use. Such sharp cuts in power supply or too high voltage can cause machines to cease, thereby initiating sparks which can cause fires. High voltages are known to melt down wires thereby bridging the wires and cause fire incidents both in factories and homes. Very low voltage on the other hand causes the windings of motors to heat up and breakdown the coil insulations resulting again in fires.

The fact that standby generators are now common place in Nigeria industrial establishments in itself constitutes unsafe condition. This is because such environments are characterized by storage of petroleum, which are very volatile.

4.3.4 FLOOR CONDITIONS / PLANT LAYOUT

Under normal circumstances, factory or plant floor are properly laid out by expert such that the movement of machines, raw materials and workers are ordered and safe. However, in actual practice, these designs are not maintained. It is common to see factory floors covered with water, oil, grease, work-in-process items, or littered waste products and scraps. In some situations, machines for moving products such as trolleys or pallets are left in the aisles. Sometimes, raw

materials or materials in process are not properly handled or kept. Thus instead of having a properly laid out factory floor, a floor littered with materials of all forms is used for production. Such floors create unsafe environment for work and cause increases in time required to accomplish specific operations.

.5 USE OF CHEMICALS

In many engineering production facilities, chemicals are used. The chemical may be a product of the enterprise, a raw material for production or an additive that is required in the process of production. Whatever the use, the chemical needs to be handled carefully. Otherwise, it can affect the workers either by being inhaled or by entering their eyes or skins. The chemical can also damage production machines by causing surface wear and rust.

When the chemicals are finally disposed of, they can pollute the environment by getting into the soil and the surface water as the case may be thereby making crops grown within the vicinity to be unfit for human consumption.

6 HUMAN BEHAVIOR

Human activities can create unsafe environment in many ways. In most cases this is through negligence and ignorance of safety practices. One of the requirements for working in an engineering environment is proper dressing which must fit the nature of work being performed. For example, an operator of machines on a factory floor should be dressed in overall, work boots, helmet, gloves and sometimes eye shield or

goggles. Workers in gaseous or dusty environments are expected to put on nose masks.

Workers operating machines should pay rapt attention and should avoid side distractions or talks. Failure to do this can lead to very serious consequences. Workers are also expected to keep close watch on their machines and to switch-off if there is any malfunction or unusual noise or vibration.

The attention of the maintenance team should be sought immediately as a faulty machine or a machine which is inadequately maintained can lead to an unsafe condition.

EFFECT OF ACCIDENTS

The effect of accidents can be grouped into three namely (i) human injury or death, (ii) time loss, and (iii) material or equipment damages. The most common effect of accident is human injury. This can vary from simple loss of a finger to the extreme case of death. The ultimate effect of this is economic loss, as the staff has to be treated in hospital at the company's expense. If the injury is serious, damages are usually claimed by the worker. If the accident does not involve a human injury, it may result in the damage of raw materials or machines. These raw materials and machines are expensive and eventually result in loss of revenue for the factory. It can be seen clearly that accidents are expensive and should be avoided at all costs. The cost associated with workplace accidents (injuries and deaths) fall into broad categories which has the following:

- Lost of work hours
- Medical expenses

(iii) Insurance premium and administration

(iv) Property damage

(v) Indirect costs.

Accidents that do not lead to injuries or damages do however translate to loss of production time which implies loss of revenue also (e.g. a carpenter on the house roof whose hammer slips off the ground).

PREVENTION OF ACCIDENTS IN ENGINEERING PRACTICE

dents in the workshops and factories do not just occur. Rather, they are ed by people. The categories of people concerned with the accidents nclude those who are ignorant of the rules that make for safety and peaceful ionship between man and machinery, and those who are over confident, -free and do not expect the unexpected during the use of workshop tools, ines and equipment. To avoid accidents, the following must be rved:

- Obey all safety rules and signs
- Follow instructions of operations. If you don't know, ask from somebody who knows.
- Correct all unsafe conditions or make them known to the person(s) responsible for their correction.
- Use the right protective equipment for the job and wear safe clothings.
- Use, adjust and repair equipment only if you are sure of how to do it.
- Use the right tool for each job, and use it correctly and safely.
- Avoid horse play on the job
- Keep your work area clean and uncrowded.

Don't wear rolled -up sleeves or loose fittings floppy shirt, pocked flaps or loose apron strings; shoes with worm soles or run-down heels. Wear overalls and work boots.

Don't wear anything hanging from around the neck, long tie, watch, chains, rings, pins or any other jewellery that might catch-up easily with the machine tool or hinders proper hand-gripping of tools.

Avoid smoking around all inflammable areas, chemical industries and petroleum storage section of the workshop/factory.

Avoid using your hand to remove cut metals or chips from a machine while the machine is still rotating.

Avoid putting sharp and dangerous tools into your pocket.

Make it a duty to keep everything in the workshop in their proper and safe places.

Ensure a good working environment in the work area for the workers and for easy flow of materials in process.

Make provision for storing or keeping raw materials, finished products, wastes and tools.

Remove all the wastes as soon as they are generated and do not allow oily liquids to flow on the floor of the workshop.

Provide a pathway for the incoming raw materials or the exit of finished products and for workers. Also provide free exits in case of an emergency.

Provide protective guards for all moving components and machines, e.g. grinding machines, belt-driven machines and very importantly, electric fans and blowers should be protected with wire mesh.

Ensure proper ventilation of the workshop especially in areas where fumes and smokes are produced so that they are exhausted into the

atmosphere as soon as they are produced. Good ventilation reduces high temperature normally associated with busy workshops and factories.

xxi) Provide fire – fighting equipment, ensure regular checks of their performance and ensure all staff are conversant with the fire fighting procedures.

3.6 HEALTH AND SAFETY REGULATIONS

Health and safety regulations are generally written in the factory Acts which is the responsibility of the ministry of Labour. The Acts are based on the recommendations of the Trade Unions, Employees' Associations, Ministry of Health and Industries. In general, the Factory Act as it affects the health and safety of workers are enforced by factory Inspectors. The Inspectors can enter any factory premises if it is felt that the Acts are being neglected. They can prosecute erring factory owners, request for the correction of faulty safety equipment, stop production, declare premises unsafe and dangerous for industrial production, and may order the seizure of the dangerous equipment. The most important factory Act in Nigeria is the Nigerian Factories Decree of 1987 and other subsidiary legislation under it. These are administered by the Factory Inspectorate Department (FID) of the Federal Ministry of Labour and Productivity. This Department has the statutory responsibility for safety, health and welfare of persons employed in factories and similar engineering establishment throughout Nigeria. The Factory Inspectorate Department enforces these provisions through regular inspection of factories, docks, wharves, rail and other mechanical workplaces that fall within the definition of a factory under the Decree.

Philosophy of Science

The philosophy of science is a field that deals with what science is, how it works, and the logic through which we build scientific knowledge. It is the philosophy and ideal that scientists hold and that they believe they should ascribe to. Philosophy of science is a branch of philosophy concerned with the foundations, methods, and implications of science. The central questions concern what counts as science, the reliability of scientific theories, and the purpose of science. This discipline overlaps with metaphysics, ontology and epistemology, for example, when it explores the relationship between science and truth. There is no consensus on many central problems in philosophy of science, including whether science can reveal the truth about unobservable things and whether scientific reasoning can be justified at all. In addition to these general questions about science as a whole, philosophers of science consider problems that apply to particular sciences such as biology or physics. Some philosophers of science also use contemporary results in science to reach conclusions about philosophy. Despite its straightforward name, the field is complex and remains an area of current inquiry.

Philosophers of science actively study such questions as:

- What is a law of nature? Are there any in non-physical sciences like biology and psychology?
- What kind of data can be used to distinguish between real causes and accidental regularities?
- How much evidence and what kinds of evidence do we need before we accept hypotheses?
- Why do scientists continue to rely on models and theories which they know are at least partially inaccurate (like Newton's physics)?

Though they might seem elementary, these questions are actually quite difficult to answer satisfactorily. Opinions on such issues vary widely within the field (and occasionally part ways with the views of scientists themselves — who mainly spend their time *doing* science, not analyzing it abstractly). Despite this diversity of opinion, philosophers of science can largely agree on one thing: there is no single, simple way to define science!

Though the field is highly specialized, a few touchstone ideas have made their way into the mainstream. Here's a quick explanation of just a few concepts associated with the philosophy of science, which you might (or might not) have encountered.

- **Epistemology** — branch of philosophy that deals with what knowledge is, how we come to accept some things as true, and how we justify that acceptance.
- **Empiricism** — set of philosophical approaches to building knowledge that emphasizes the importance of observable evidence from the natural world.
- **Induction** — method of reasoning in which a generalization is argued to be true based on individual examples that seem to fit with that generalization. For example, after observing that trees, bacteria, sea anemones, fruit flies, and humans have cells, one might *inductively* inferthat all organisms have cells.
- **Deduction** — method of reasoning in which a conclusion is logically reached from premises. For example, if we know the current relative positions of the moon, sun, and Earth, as well as exactly how these move with respect to one another, we can *deduce* the date and location of the next solar eclipse.
- **Parsimony/Occam's razor** — idea that, all other things being equal, we should prefer a simpler explanation over a more complex one.
- **Demarcation problem** — the problem of reliably distinguishing science from non-science. Modern philosophers of science largely agree that there is no single, simple criterion that can be used to demarcate the boundaries of science.
- **Falsification** — the view, associated with philosopher Karl Popper, that evidence can only be used to rule out ideas, not to support them. Popper proposed that scientific ideas can only be tested throughfalsification, never through a search for supporting evidence.
- **Paradigm shifts and scientific revolutions** — a view of science, associated with philosopher Thomas Kuhn, which suggests that the history of science can be divided up into times of normal science (when scientists add to, elaborate on, and work with a central, accepted scientific theory) and briefer periods of revolutionary science. Kuhn asserted that during times of revolutionary science, anomalies refuting the accepted theory have built up to such a point that the old theory is broken down and a new one is built to take its place in a so-called "paradigm shift."

Philosophy of science as epistemology and metaphysics

Apart from any philosophical interest that we may have in science because of its status and influence on our lives, science is important to philosophy because it seems to offer answers to fundamental philosophical questions. One such question is 'how can we have knowledge as opposed to mere belief or opinion?', and one very general answer to it is 'follow the scientific method'. So, for example, whatever any of us may believe, rightly or wrongly, about whether smoking causes cancer or traffic fumes cause asthma, a government will not act unless there is scientific evidence supporting such beliefs (of course, they may still not act even when there is evidence). Similarly, in all the examples mentioned above, respect is accorded to the views of scientists because their conclusions are supposed to have been reached on the basis of proper methods of gathering and assessing evidence, and hence are supposed to be justified. ***The branch of philosophy that inquires into knowledge and justification is called epistemology***. The central questions of epistemology include: what is knowledge as opposed to mere belief?; can we be sure that we have any knowledge?; what things do we in fact know?. The first of these is perhaps the most fundamental epistemological question. Each of us has many beliefs, some true and some false. If I believe something that is, as a matter of fact, false (suppose, for example, that I believe that the capital city of Australia is Sydney) then I cannot be said to know it. In logical terminology we say a **necessary condition**, which is a condition that must be satisfied, for somebody knowing some **proposition** is that the proposition is true.

In other words, if somebody knows some proposition then that proposition is true. (The converse obviously does not hold; there are lots of propositions that are true but which nobody knows, for example, there is a true proposition about how many leaves there are on the tree outside my window, but I presume nobody has bothered to find out what it is.) Where someone believes something that turns out to be false (no matter how plausible it seemed) then we would say that they thought they knew it but that in fact they did not. Suppose too that another necessary condition for somebody knowing some proposition is that he or she believes that proposition. We now have two necessary conditions for knowledge; knowledge is at least true belief, but is that enough? Consider the following example: suppose that I am very prone to wishful thinking and every week I believe that my numbers will come up on the lottery, and suppose that one particular week my numbers do in fact come up; then I had a belief, that my numbers would come up, and it was a true belief, but it was not knowledge

because I had no adequate reason to believe that my numbers would come up on that particular week rather than on all the other weeks when I believed they would come up, but when they did not. Hence, it may be the case that I believe something, and that it is true, but that I do not know it. So it seems that for something someone believes to count as knowledge, as well as that belief being true, something else is required. My belief about the lottery in the example above did not count as knowledge because I lacked an adequate reason to believe that I would win that week; we would say that my belief was not justified. The traditional view in epistemology has been that knowledge can only be claimed when we have an adequate justification for our beliefs, in other words, knowledge is *justified* true belief. Although recently this 'tripartite' definition of knowledge has been the subject of much criticism and debate, justification is still often regarded as necessary for knowledge. This brings us to the issue of what justification amounts to and, as suggested above, justification is often thought to be provided by following scientific methods for testing or arriving at our beliefs (the word science comes from the Latin word *scientia*, which means knowledge). So one area of philosophy that overlaps considerably with philosophy of science is epistemology.

The epistemological questions that are addressed in later chapters (along with some of the competing answers to them) include the following. What is the scientific method? How does evidence support a theory? Is theory change in science a rational process? Can we really be said to know that scientific theories are true? If we accept the idea that science really does give us some sort of knowledge then we must examine what scientific theories tell us about how the world is, and decide what is the scope of scientific knowledge. The modern scientific picture of the world seems to tell us a great deal, not just about how things are now, but how they were millions and even billions of years ago. Astrophysics tells us about the formation of the Earth, the solar system and even the universe, geophysics tells us about the development of mountains, continents and oceans, and biochemistry and evolutionary biology tell us about the development of life itself. Such scientific theories tell us more about familiar things, so, for example, we may learn where a particular river used to flow or how bees pollinate flowers. However, scientific theories, especially those in physics and chemistry, also describe entities that are not part of our everyday experience, such as molecules, atoms, electromagnetic waves, black holes, and so on. Such theories raise particular problems and questions in the philosophy of science; for example, should we

believe in the existence of such esoteric and unobservable entities, and if so, what is to count as evidence for their existence and how do we manage to refer to them?

Of course, science does not just describe the world; it also gives us explanations of how and why things are as they are. Often this involves describing unobservable causes of things we observe. Hence, Newton is not famous for discovering that unsupported objects fall to the Earth, he is famous for explaining why they do so (the gravitational force is what causes apples to fall out of trees), and for giving us a law that allows us to calculate the rate at which they do so.

Newton's mechanics, like many scientific theories, is formulated in terms of a few fundamental principles or laws. Central to our understanding of science is this idea of *laws of nature*; for example, it is supposed to be a law of nature that all metals expand when heated.

So science seems to tell us about the ultimate nature of things, what the world is made of and how it works. It has even been thought that science has replaced **metaphysics** not just by telling us about what exists, and explaining what happens in terms of laws of nature and causation, but also by answering other fundamental philosophical questions about, say, the nature of space and time. But what exactly is a law of nature, and what does it mean to say that something has caused something else? What is it to explain something?

Many philosophers and scientists take it for granted that the aim of science is not merely to describe what we see, but also to arrive at the truth about the unobservable entities, laws and causes that lie behind the phenomena we observe. On the other hand, there is also a long tradition of disregarding questions about the real nature of things, the laws of nature and so on, and emphasising instead the search for theories that accurately predict what can be observed, without worrying about whether they are true or false beyond that. The question on which this book will focus is, 'ought we to believe in the unobservable entities postulated by our best scientific theories?', or more crudely,'do electrons really exist?'. You might think this question makes little sense because electrons are, in fact, observable. After all, don't television sets work by firing electrons at a phosphorus screen, and so don't we, indirectly at least, observe electrons all the time? Scientific realism is the view that we should believe in the likes of electrons, whereas scientific antirealism is the view that we should stop short of believing in the truth of scientific theories and content ourselves with believing what they say about what we can observe. In trying to decide the issue of scientific realism we will have to address all the epistemological and metaphysical questions mentioned above along the way.

Philosophy of science asks about numerous issues.

- **What is a theory and what is a law of science?** The two are often conflated but have well defined meanings; a "law" is unbroken, such as the law that gravity causes things to fall, but might not be totally *proved*, such as the laws of thermodynamics which are mostly observed empirically and aren't necessarily true all of the time in all conditions. The second law of thermodynamics, for example, has only a statistical certainty of operation and can conceivably be violated in individual cases.
- **Realism and anti-realism:** To what extent to scientific theories describe reality? Are scientific theories primarily tools for prediction and control, or do they aim at description of a mind-independent reality? If so, what parts do so? Which theories? What does it mean for a scientific theory to be "correct?"
- **What is scientific explanation?** Why are scientific explanations so successful? What makes something a good explanation? Are explanations primarily causal, logical, or something else? Are explanations in different sciences structurally similar, or do they each have their own "logic?"
- **Reduction and emergence:** What is reductionism? To what degree is reductionism possible? How do, e.g. biological explanations and concepts relate to physical explanations and concepts? What does it mean for a phenomenon to be "emergent?" Are the sciences converging on an increasingly unified picture of the world, or are they fragmentary, giving us only partial and increasingly domain-specific descriptions?
- **What is falsifiability?** Falsifiability is often taken to be a "litmus test" of science - it means that a claim can be falsified, or shown to be not true. Atomic theory could be falsified by showing a chemical reaction that wasn't stoichiometric, for example. Supernatural explanations on the other hand cannot be falsified; as by definition proponents of supernatural explanations will put themselves outside the realms of actual testing.
- **What is and is not "scientific"?** This is known as the Demarcation problem. Many people defer to Karl Popper on this, who was a great proponent of the idea that science rests *entirely* on falsifiability. Within the philosophy of science community, Popper's falsificationism is widely criticized. Work in contemporary philosophy of science largely ignores the demarcation problem.
- **What is the definition of *Direct observation*?** For instance, how many layers of theoretical observation can be applied, before you are no longer directly observing and before the theory laden tools compromise the term "direct observation".

For instance: I see a leaf. I use a single lens magnifying glass to see the leaf. I use a double lens Microscope to see the leaf. Based on theory of electrons, I look at the leaf with electron microscope. Based on other theories, I look at the light under UV scopes... this could be taken down to the atomic level, as atoms are too small to be observed by visible light, so their existence must be inferred from other regions of the electromagnetic spectrum; X-Rays for diffraction or NMR to observe the magnetic moment of the nucleus.

- **What are, if any, the ramifications of theory laden observation?**
- **What defines the natural world?**
- **What is the limit of scientific reasoning?** Where (if anywhere) does "science" cross into "non-science" when talking about things like Chaos Theory, String theory, and other non-empirical driven science. This is a special case of the demarcation problem.

Who's who in the philosophy of science

Aristotle (384-322 BC) — Arguably the founder of both science and philosophy of science. He wrote extensively about the topics we now call physics, astronomy, psychology, biology, and chemistry, as well as logic, mathematics, and epistemology.

Francis Bacon (1561–1626) — Promoted a scientific method in which scientists gather many facts from observations and experiments, and then make inductive inferences about patterns in nature.

Rene Descartes (1596–1650) — Mathematician, scientist, and philosopher who promoted a scientific method that emphasized deduction from first principles. These ideas, as well as his mathematics, influenced Newton and other figures of the Scientific Revolution.

Piere Duhem (1861–1916) — Physicist and philosopher who defended an extreme form of empiricism. He argued that we cannot draw conclusions about the existence of unobservable entities conjectured by our theories such as atoms and molecules.

Carl Hempel (1905-1997) — Developed influential theories of scientific explanation and theory confirmation. He argued that a phenomenon is "explained" when we can see that it is the logical consequence of a law of nature. He championed a hypothetico-deductive account of confirmation, similar to the way we characterize "making a scientific argument" in this website.

Karl Popper (1924-1994) — Argued that falsifiability is both the hallmark of scientific theories and the proper methodology for scientists to employ. He believed that scientists should always regard their theories with a skeptical eye, seeking every opportunity to try to falsify them.

Thomas Kuhn (1922-1996) — Historian and philosopher who argued that the picture of science developed by logical empiricists such as Popper didn't resemble the history of science. Kuhn famously distinguished between normal science, where scientists solve puzzles within a particular framework or paradigm, and revolutionary science, when the paradigm gets overturned.

Paul Feyerabend (1924-1994) — A rebel within the philosophy of science. He argued that there is no scientific method or, in his words, "anything goes." Without regard to rational guidelines, scientists do whatever they need to in order to come up with new ideas and persuade others to accept them.

Evelyn Fox Keller (1936-) — Physicist, historian, and one ofthe pioneers of feminist philosophy of science, exemplified in her study of Barbara McClintock and the history of genetics in the 20th century.

Elliott Sober — Known for his work on parsimony and the conceptual foundations of evolutionary biology. He is also an important contributor to the biological theory of group selection.

Nancy Cartwright (1944-) — Philosopher of physics known for her claim that the laws of physics "lie" — i.e., that the laws of physics only apply in highly idealized circumstances. She has also worked on causation, interpretations of probability and quantum mechanics, and the metaphysical foundations of modern science.